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AN EVALUATION OF PARAMETERS CONTROLLING FINE PARTICLE CLASSIFICATION USING A MOZLEY HYDROCYCLONE

P.R.A. Andrews and L. Morin
Mineral Processing Laboratory

October 1986

Project: 30.13.03
Evaluation of Mineral Processing Equipment

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26 pp

MINERAL SCIENCES LABORATORIES
DIVISION REPORT MSL 86-147 (IR)

MICROMEDIA

AN EVALUATION OF PARAMETERS CONTROLLING FINE PARTICLE CLASSIFICATION USING A MOZLEY HYDROCYCLONE

P.R.A. Andrews* and L. Morin**

ABSTRACT

A Mozley laboratory hydrocyclone was evaluated for desliming and classification of fine particle slurries. The evaluation involved measuring the effect that both principal and secondary parameters had on the cut point size of the cyclone overflow.

The principal parameters studied included vortex finder (cyclone overflow), spigot discharge diameter (cyclone underflow), feed pressure, and feed density. Secondary parameters were specific gravity and high % weight of -5µm material.

A series of test conditions was established for classifying 1 to 2 kg of ± -75 µm feed such that a range of cut points between 5 µm and 20 µm could be obtained.

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* Research Scientist and **Technician, Non-Metallic Minerals Section, Mineral Processing laboratory, Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada, Ottawa

ÉVALUATION DES PARAMÈTRES RÉGISSANT LA CLASSIFICATION DES PARTICULES FINES À L'AIDE D'UN HYDROCYCLONE MOZLEY

P.R.A. Andrews* et L. Morin**

RÉSUMÉ

On a évalué la capacité de deschlammage et de classification de suspensions de fines particules d'un hydrocyclone de laboratoire Mozley. L'évaluation a consisté à mesurer l'effet des paramètres principaux et secondaires sur la dimension de coupure de la surverse du cyclone.

Voici les principaux paramètres étudiés : diamètre de la tubulure d'évacuation des fines (surverse du cyclone), diamètre de la tubulure d'évacuation du refus (sous-verse du cyclone), pression d'alimentation et densité de la charge d'alimentation. On a également étudié les paramètres secondaires suivants : densité et pourcentage massique élevé des particules de -5 µm.

On a établi une série de conditions d'essai pour classifier 1 à 2 kg d'une charge d'alimentation d'environ -75 µm, de manière à pouvoir obtenir une gamme de dimensions de coupure de 5 µm à 20 µm.

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* Chercheur scientifique et ** technicien, Section des minéraux non métalliques, Laboratoire de traitement des minéraux, Centre canadien de la technologie des minéraux et de l'énergie, Énergie, Mines et Ressources Canada, Ottawa.

INTRODUCTION

The Mozley hydrocyclone test rig was developed by Richard Mozley Ltd., Falmouth, Cornwall, England. The instrument was purchased in late 1982 as part of the Non-Metallic Mineral Section's programme of fine particle classification (in the -10μm range).

DESCRIPTION

The test rig, shown in Fig. 1, is a combination hydrocyclone and pumping system. It is powered by a small motor, with the whole assembly being mounted on a trolley. A MONO pump is driven via 'V' belts by a 2 h.p. electric motor. Alternative drive pulleys were provided to enable the pump speed to be matched to a particular hydrocyclone. Two Mozley polyurethane hydrocyclones, 25 mm and 50 mm in diameter complete with all fittings, also were supplied. Each hydrocyclone has a range of interchangeable vortex finders and spigot discharge caps with different outlet diameters to enable cut points from 2 to 15 μm to be achieved.

A polypropylene sump serves as a reservoir from which the pump delivers slurry to the particular hydrocyclone. A by-pass valve and pressure gauge enable accurage control of the hydrocyclone feed pressure.

PRINCIPLE OF OPERATION

The feed slurry enters the hydrocyclone tangentially under pressure, as shown in Fig. 1. The high centrifugal forces generated within the feed chamber shown as A in Fig. 1 cause particles coarser than a given cut point (determined by size of hydrocyclone, vortex and spigot diameters) to migrate into the primary vortex adjacent to the wall and to move downwards to discharge with a small volume of water via the spigot, shown as B in Fig. 1. Particles finer than the cut point migrate into the secondary upward moving vortex, along the axis of the hydrocyclone and discharge with a large volume of water via the vortex finder, shown as C in Fig. 1.

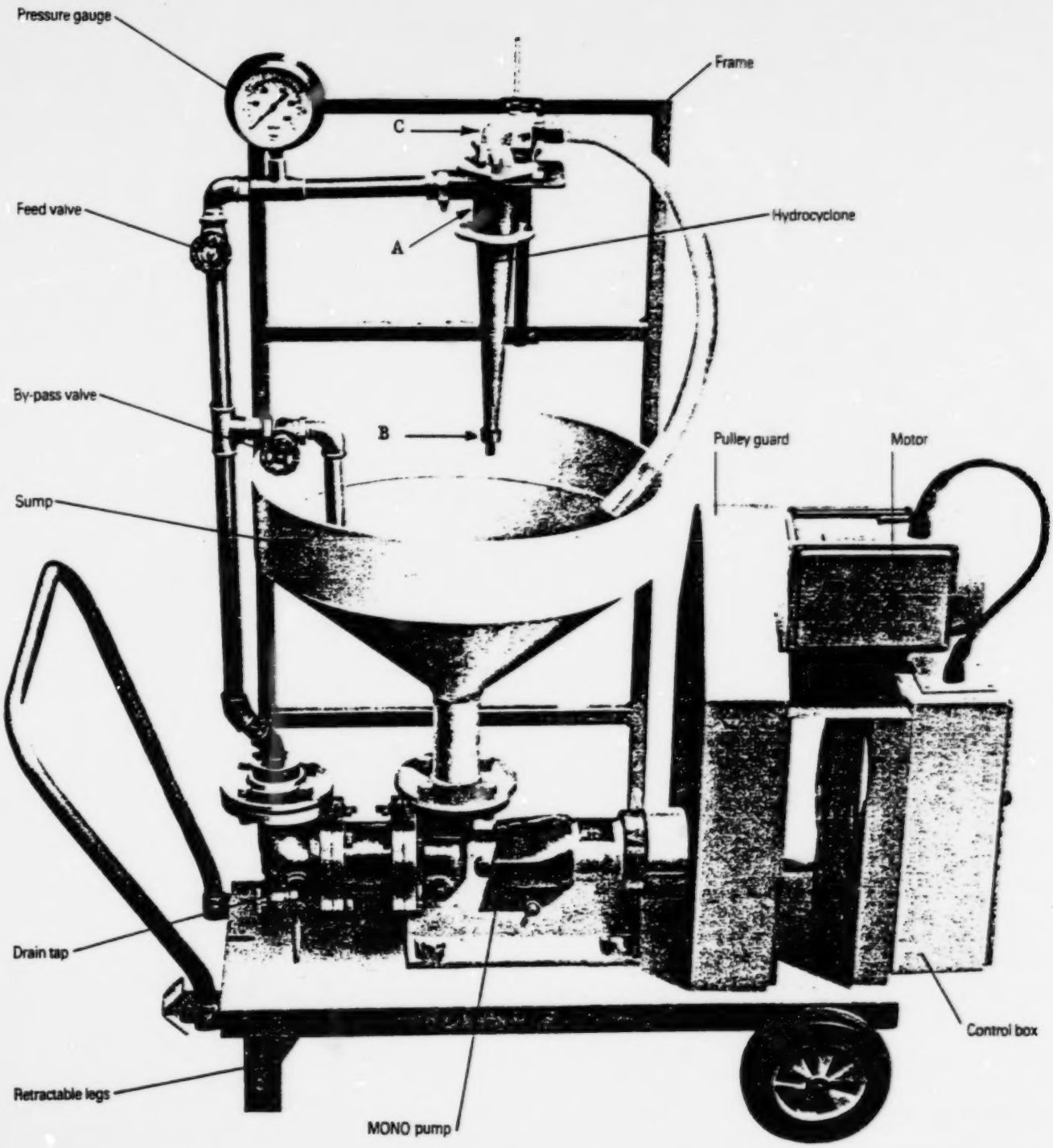

Fig. 1 - Mozley hydrocyclone test rig assembly, shown mounted on a trolley

OPERATING PROCEDURE

The performance of a hydrocyclone depends on many variables, principal variables being operating pressure and diameters of the vortex finder (overflow) and spigot discharge (underflow) outlets. In general, a high operating pressure will give a sharper cut at a finer cut point size.

Before beginning a test the appropriate hydrocyclone vortex finder and spigot discharge are fitted, and the correct pulleys to give the necessary pump speed for the hydrocyclone being used are mounted on the motor and pump shafts. These details are available in the manufacturers operating manual([1]). The by-pass valve is opened and the valve in the cyclone feed line is closed.

The conical sump is half filled with water or a slurry of feed and water. Since the rig is equipped with a MONO pump, the pump must not be operated without fluid in the sump. If the material to be classified is already a slurry, the pump should be started immediately to prevent sanding. The rig is designed to operate only on material finer than 100 μm to help minimize the effect of settling out.

The motor is switched on and immediately water or slurry will circulate through the by-pass line. If only water is in the sump, then the material to be classified is added slowly to the sump. When the slurry is completely dispersed, additional water is added until the required pulp density is reached. The distance between the slurry level and the base of the hydrocyclone should be sufficient to allow for sampling of the cyclone underflow. The cyclone feed line valve is opened to allow feed material to flow into the hydrocyclone. Both overflow and underflow products should discharge back into the sump. At the same time the by-pass valve is partially closed until the pressure gauge registers 15 p.s.i. The system is checked for leaks before further closing the by-pass valve to achieve a pressure of 50 p.s.i.

When the overflow and underflow products are in equilibrium, that is when the underflow is not roping but rather exhibiting the characteristic spray discharge, the system can be sampled. Sampling is conducted by simultaneously collecting the underflow and overflow products for a specific period of time. Sampling in this manner does not alter the characteristics

of the remaining feed material in the sump. If further testwork is to be conducted using different operating pressures, vortex finder or spigot discharge diameters, the cyclone feed line valve is closed and the by-pass line opened. Thus the remaining feed material will continue to circulate while the necessary changes are made.

The products from classification can either be used for calculating pulp density or size analysis to determine the cut point size. A convenient and accurate method of measuring size is the laboratory Sedigraph, which measures size based on Stokes Law. The cut point as measured by the Sedigraph is the point of maximum rate of incremental change (see Appendix I).

SCOPE OF INVESTIGATION

An important application of the hydrocyclone test rig is the desliming of sub-micron particles in slurrys of very soft minerals, preparatory to further benefication. Talc is prone to the production of slime material and for this reason was chosen for investigation. The effects of operating feed pressure, feed pulp density, spigot discharge, and vortex finder size on the cut point size of the cyclone overflow were investigated. The range of numerical values over which these parameters were studied are as follows:

Feed pressure (p.s.i.)	30, 40, 50
Feed pulp density (% solids)	2.5, 5.0, 7.5, 10.0
Spigot discharge diameter (mm)	1.6, 3.2, 4.8
Vortex finder diameter (mm)	3.2, 4.8

Other parameters which effect cut point size were briefly investigated: e.g., specific gravity and high % weight of -5μm slime.

MINERALS TESTED

A sample of talc that previously had been ground by a Raymond roller mill to 94% -53μm, of which the maximum particle size was ≈75μm, and ≈40% reporting in the -20μm fraction was chosen for investigation. A brief

evaluation also was conducted on a sample of -50μm barite, to determine the effect of specific gravity on cut point size. A sample of kaolin, wet screened at 44μm, of which ≈63% was -5μm, was evaluated to determine the effect of a high proportion of slime size material on the cut point size. Size distribution of each mineral is reported in Fig. 2.

TESTWORK PROCEDURE

The 25 mm hydrocyclone, fitted with a 3.2 mm aperture vortex finder and 1.6 mm spigot discharge cap, was assembled on the test rig. A sample of 94% -53μm talc was fed to the hydrocyclone at 30 p.s.i. operating feed pressure using 2.5% solids feed pulp density. When the system was in equilibrium timed samples of the cyclone overflow and underflow, each of 7 sec. duration, were obtained simultaneously. A time of 7 sec was chosen as this was the minimum time required to obtain sufficient weight of cyclone overflow to accurately measure pulp density. The procedure was repeated at 40 and 50 p.s.i. feed pressures and 7 sec samples of cyclone overflow and underflow at each feed pressure were again obtained when the system was considered to be in equilibrium.

The cyclone unit was then emptied and flushed with clean water and a second series of tests were conducted at 5% solids, using the same values of spigot discharge diameter, vortex finder diameter and feed pressure. A third and fourth series were conducted at 7.5% and 10% solids. At the completion of the fourth series, the spigot discharge diameter was increased to 3.2 mm. Four further tests were conducted using feed pressures of 30, 40 and 50 p.s.i. at 2.5, 5.0, 7.5 and 10.0% solids feed pulp density, while maintaining the vortex finder diameter unchanged. Test series 9 to 12 were conducted using the coarsest spigot discharge diameter (4.8 mm). On completion of Test 12 the vortex finder diameter was increased to 4.8 mm and Tests 13 to 24 conducted using identical conditions to Tests 1 to 12 except for the increased vortex finder diameter.

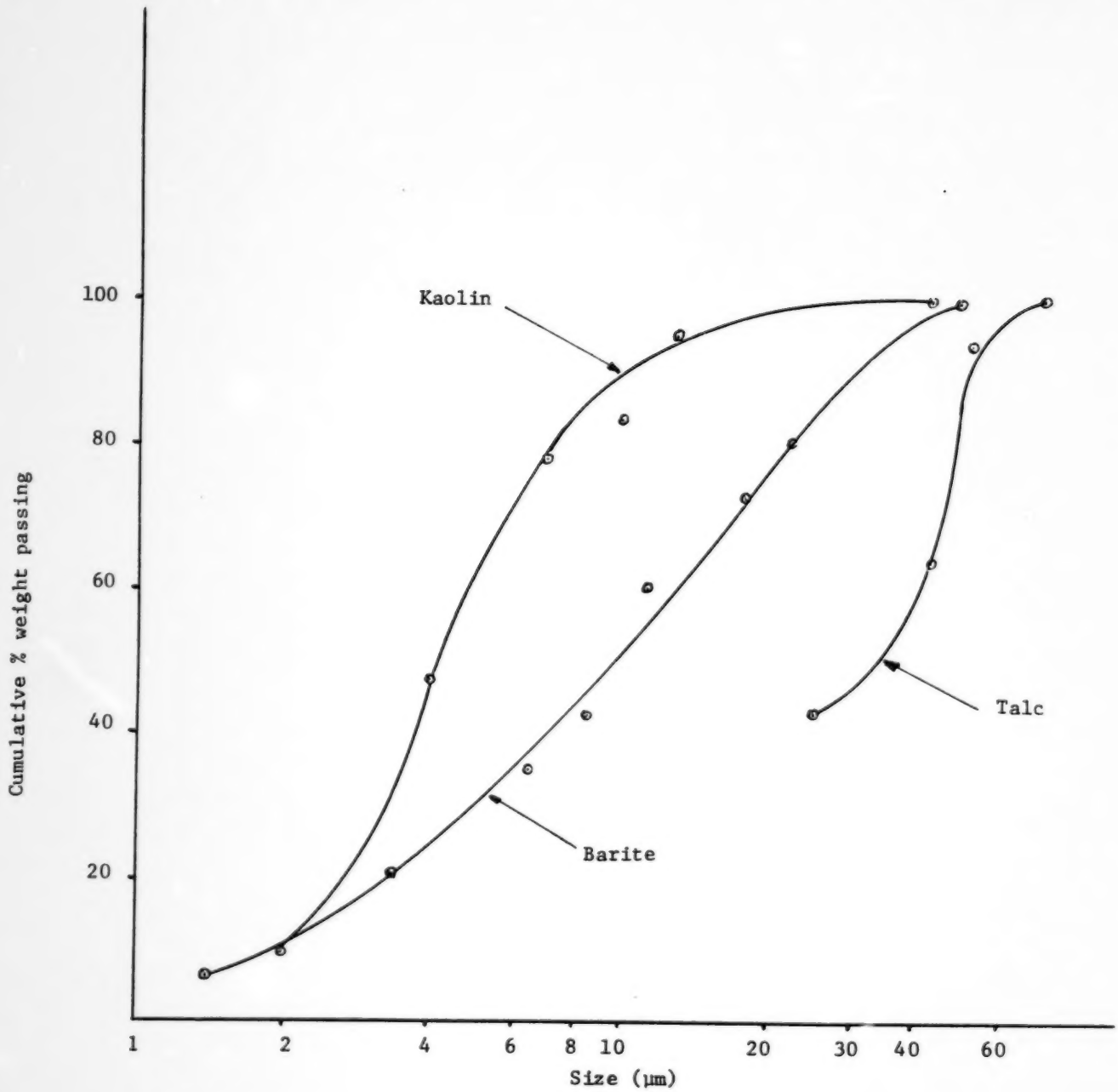

Fig. 2 - Size distributions of barite, kaolin and talc samples

On completion of Test 24, when all the main parameters had been evaluated, the various cyclone overflow and underflow products were weighed wet, filtered, weighed dry and the pulp density of each calculated. A small portion of each cyclone overflow (wet) was separated and used for calculation of the cut point size using a laboratory Sedigraph.

Test results are reported in Table 1.

RESULTS

1. Vortex finder 3.2 mm (finest overflow)
   Spigot discharge 1.6 mm (finest underflow)
   Runs 1 to 4, Table 1

A slight decrease in cut point size was noted with increasing feed pressure at feed densities of 5.0 and 7.5%s. An apparent increase in cut point size at 10%s is possibly due to unbalance caused by high pulp density overloading. The finest overflow/finest underflow system would be most sensitive to unbalance since the restricted apertures would require longer times to reach equilibrium than the coarser size apertures.

No significant trend was noted at 50 p.s.i. feed pressure in either increased or decreased cut point size while increasing feed density from 2.5 to 10.0%s. Cut point size remained unchanged at 16.3µm*, although there was a slight decrease in size at 5.0 and 7.5%s.

The variation of cyclone underflow density with increasing feed density is reported in Fig. 3.

2. Vortex finder 3.2 mm (finest overflow)
   Spigot discharge 3.2 mm (medium underflow)
   Runs 4 to 8, Table 1

The only significant decrease in cut point size while increasing feed pressure was noted for 2.5%s feed density. The apparent increase in cut point size at 10%s is again possibly due to high pulp density overloading.

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* Cut point size is calculated from a logarithmic scale (see Appendix).

With this system the spigot discharge has been increased, which will reduce the load on the cyclone overflow, but the system is still controlled more by the finest vortex finder size. In consequence of this, the average cut point size, at 50 p.s.i., was only slightly decreased to 12.8μm as compared with 16.3μm in Runs 1 to 4.

Again there was no significant trend noted, at 50 p.s.i. feed pressure, in either increased or decreased cut point size, while increasing feed density from 2.5 to 10.0%s.

The variation in cyclone underflow density with increasing feed density is reported in Fig. 3.

3. Vortex finder 3.2 mm (finest overflow)
   Spigot discharge 4.8 mm (coarsest underflow)
   Runs 9 to 12, Table 1

With this system the spigot discharge is at the coarsest value which reduces the load still further on the overflow. This reduction in load results in a more efficient system, that is, the trend towards reduced cut point size while increasing feed pressure. There is a significant reduction in cut point size at both 2.5 and 5.0%s feed densities; a less significant reduction at 7.5%s. As before the apparent increase in cut point size at 10.0%s feed density is possibly due to high pulp density overloading.

As with Runs 1 to 4 and 5 to 8, there was no significant trend noted at 50 p.s.i. feed pressure, in either increased or decreased cut point size, while increasing feed density from 2.5 to 10.0%s, although a slight increase, from 13.5μm at 2.5%s to 14.6μm at 10.0%s, was recorded.

The variation of cyclone underflow density with increasing feed density is reported in Fig. 3.

4. Vortex finder 4.8 mm (coarsest overflow)
   Spigot discharge 4.8 mm (coarsest underflow)
   Runs 13 to 16, Table 1

Increasing the vortex finder aperture results in an increased volume of water to the cyclone overflow and a corresponding increase in the cyclone underflow density. This is apparent by comparing Run 9 to Run 13, Run 10 to Run 14 etc.

The reduction in cut point size with increasing feed pressure occurs at each level of feed density, even at 10%s where the cyclone underflow is ≈22%s. At 50 p.s.i. feed pressure there is now a significant decrease in cut point size with increasing feed density, from 12.1μm at 2.5%s to 5.7μm at 10.0%s.

The variation of cyclone underflow density with increasing feed density is reported in Fig. 4.

5. Vortex finder 4.8 mm (coarsest overflow)
   Spigot discharge 3.2 mm (medium underflow)
   Runs 17 to 20, Table 1

Reduction of the spigot discharge size might be expected to disturb the trend towards decreasing cut point size while increasing feed pressure as was experienced in Runs 1 to 4 and 5 to 8. Examination of Runs 17 to 20 indicates, however, that there is a reduction in cut point size at each feed density value. Although the spigot discharge is being restricted, the widest aperture for the vortex finder restores the equilibrium.

At 50 p.s.i. the trend towards decreasing cut point size while increasing feed density is less significant. The reduction is only from 7.1μm at 2.5%s to 6.1μm at 10.0%s.

The variation of cyclone underflow density with increasing feed density is reported in Fig. 4.

6. Vortex finder 4.8 mm (coarsest overflow)
   Spigot discharge 1.6 mm (finest underflow)
   Runs 21 to 24, Table 1

The decrease of cut point size with increasing feed pressure is still evident even with the narrowest spigot discharge. Even in Run 24, where the cyclone underflow at ≈60%s was difficult to maintain as a spray discharge, the cut point size decreased from 9.6μm at 30 p.s.i. to 7.4μm at 50 p.s.i.

At 50 p.s.i. the trend towards decreasing cut point size while increasing feed density is less significant. The reduction is only from 8.6μm at 2.5%s to 7.4μm at 10.0%s.

The variation of cyclone underflow density with increasing feed density is reported in Fig. 4.

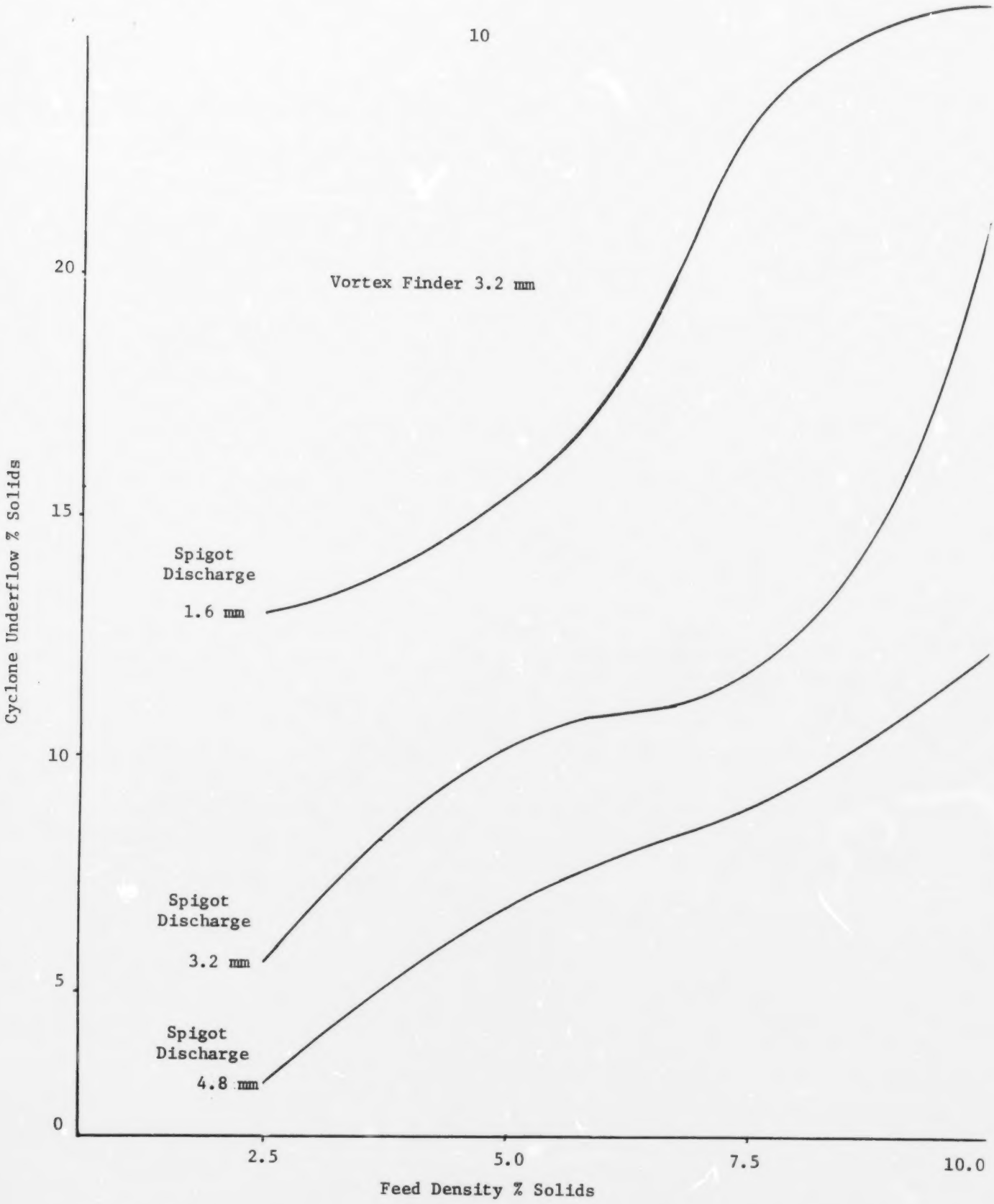


Fig. 3 - Variation of cyclone underflow density with increasing feed density and spigot discharge diameter

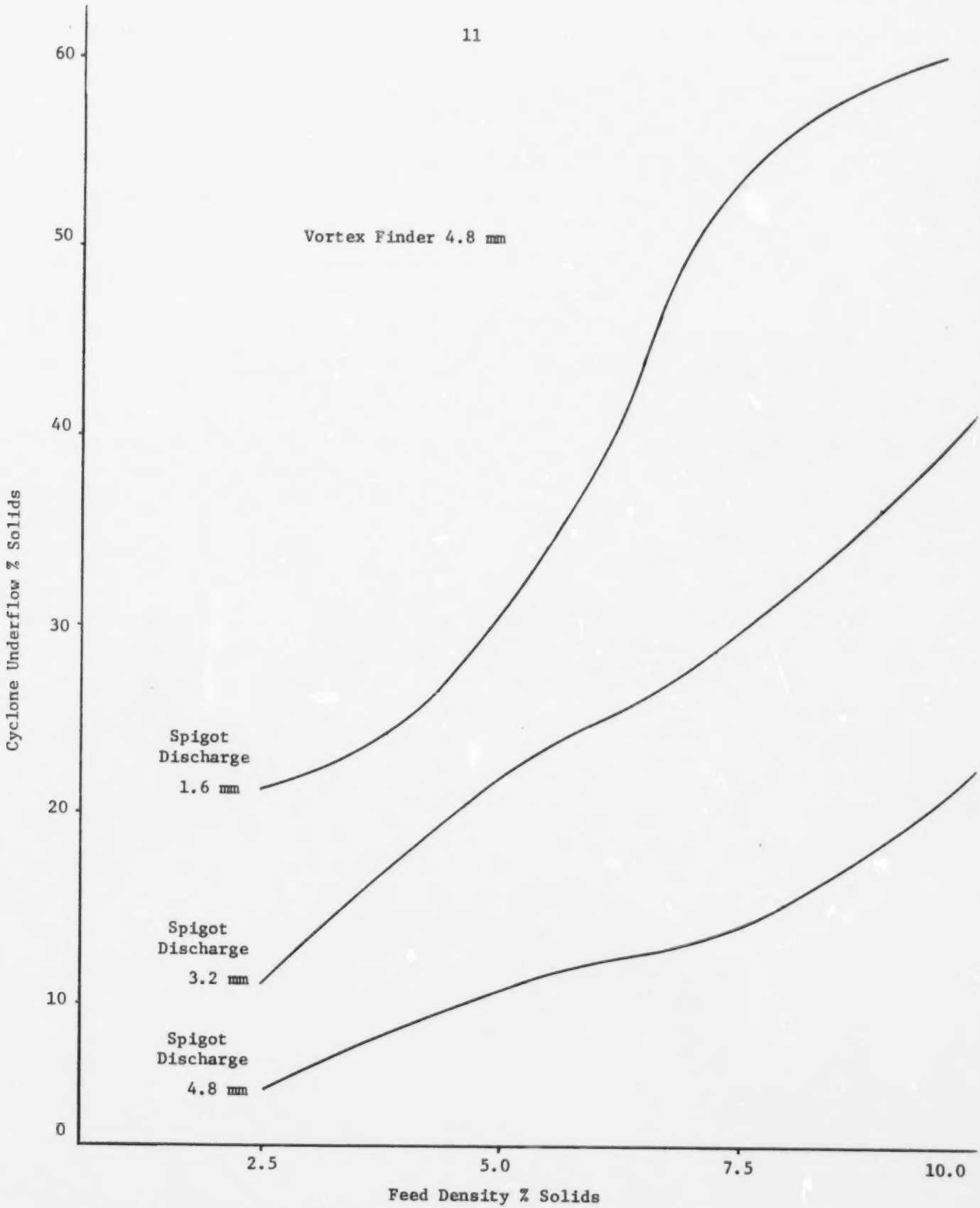


Fig. 4 - Variation of cyclone underflow density with increasing feed density and spigot discharge diameter

PRACTICAL APPLICATIONS

A particularly useful application of this apparatus is the desliming of 1 to 2 kg of previously ground flotation feed samples. A summary is presented in Table 2 of the conditions by which it would be possible to obtain deslimed flotation feeds, employing cut point sizes varying between 20µm to 5µm. By employing this guide it is conceivable that several different sized cut point fractions could be obtained from the same sample by altering the principal parameters.

INFLUENCE OF SPECIFIC GRAVITY

It is well known to users of the cyclosizer that when sizing high specific gravity products the effective passing sizes for each cone are lower than the passing sizes obtained by classifying reference quartz. A similar relationship was found to exist when classifying -50µm barite (S.G. 4.5), which results are reported in Table 3.

Six tests were conducted at 12.5%s feed density using the 4.8 mm vortex finder and each of the three spigot discharge sizes at both 40 and 50 p.s.i. feed pressure. For comparison purposes the cut point sizes obtained under identical conditions when classifying talc are shown in brackets. The conditions which produced the lowest cut point size for barite at 2µm also produced the lowest cut point size for talc at 6µm. The comparison is not strictly valid since the size distribution for each mineral was different.

INFLUENCE OF HIGH SLIME CONCENTRATION

Kaolin, when washed and separated from silica grit, tends to concentrate in the -5µm fraction. Furthermore, the volume of -5µm material produced is very high. It is important therefore that this high grade fraction be separated efficiently and, if possible, with a minimum of secondary classification to recover misplaced particles from primary classification.

A test was conducted using previously sized -44μm kaolin, which contained ≈32% -5μm material, employing the conditions of finest cut point separation established for talc. Samples of the cyclone overflow and underflow were sized using the Sedigraph. The results are presented in Appendix I. The cut point for the cyclone overflow was 2.8μm and for the cyclone underflow 10.4μm. Each cut point was well defined, with 100% of the cyclone overflow being < 5μm and only 5% of the cyclone underflow was misplaced -5μm material.

INFLUENCE OF SIZE DISTRIBUTION

The finest cut point obtained for talc was 5.7μm (vortex finder 4.8 mm, spigot discharge 4.8 mm), whereas the finest cut point obtained for barite employing similar conditions was 2μm. The influence of specific gravity was the main factor in lowering the cut point, but the size distribution of the feed material also had some effect.

This latter parameter was not investigated but the effect of size distribution was demonstrated, by inference, from the results obtained on kaolin. Approximately one third of the feed sample was -5μm and the cut point occured at 2.8μm. If there had been very little -5μm feed material the cut point would have been higher.

CONCLUSIONS

1. The parameters which most influence cut point size are vortex finder diameter (cyclone overflow) and spigot discharge diameter (cyclone underflow).

2. While maintaining constant vortex finder diameter there appears to be little variation of cut point size while varying spigot discharge diameter; more significant variation occurs when varying the vortex finder diameter while maintaining constant spigot discharge diameter.

3. The influence of increasing feed pressure in decreasing cut point size was more pronounced using the coarsest vortex finder diameter.

4. The influence of increasing feed density in decreasing cut point size was more pronounced using the coarsest vortex finder diameter.

5. Generally, the cyclone overflow density is only marginally influenced by feed density, vortex finder and spigot discharge diameter.

6. The cyclone underflow density increases with increasing feed density, while maintaining constant spigot discharge and vortex finder diameter.

7. The cyclone underflow density decreases with increasing spigot discharge diameter, while maintaining constant feed density and vortex finder diameter.

8. An increase in specific gravity of feed material will reduce the cut point size.

9. The size distribution of the feed material will influence the cut point such that an excessive portion of a particular size fraction will tend to move the cut point in the direction of that size fraction.

ACKNOWLEDGEMENTS

The authors would like to thank R.D. Joe, summer student, for assistance in the testwork programme.

REFERENCES

1. Mozley R., "Manufacturers operating manual".

Table 1. Variation of cyclone overflow cut point size for talc (94%-53μm) with various operating parameters

Run 1

Vortex Finder 3.2 mm
Spigot Discharge 1.6 mm
Feed Density 2.5%s

Feed Pressure p.s.i.	Cyclone Overflow %s	Cyclone Underflow %s	Cut point size μm
30	0.4	11.5	13.0
40	0.4	12.0	15.7
50	0.4	12.9	16.3

Run 2

Vortex Finder 3.2 mm
Spigot Discharge 1.6 mm
Feed Density 5.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size μm
0.8	16.4	15.1
0.7	15.6	12.5
0.8	15.4	12.5

Run 3

Vortex Finder 3.2 mm
Spigot Discharge 1.6 mm
Feed Density 7.5%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size μm
0.9	24.7	11.6
0.8	22.7	11.6
0.8	23.1	11.2

Run 4

Vortex Finder 3.2 mm
Spigot Discharge 1.6 mm
Feed Density 10.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size μm
1.3	27.6	10.4
1.3	25.8	13.0
1.3	25.7	16.3

Run 5

Vortex Finder 3.2 mm
Spigot Discharge 3.2 mm
Feed Density 2.5%s

Feed Pressure p.s.i.	Cyclone Overflow %s	Cyclone Underflow %s	Cut point size μm
30	0.3	5.4	20.5
40	0.2	5.6	17.6
50	0.2	5.6	13.0

Run 6

Vortex Finder 3.2 mm
Spigot Discharge 3.2 mm
Feed Density 5.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size μm
1.0	10.0	15.7
0.6	10.5	15.7
0.6	10.2	16.3

Run 7

Vortex Finder 3.2 mm
Spigot Discharge 3.2 mm
Feed Density 7.5%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size μm
0.9	10.9	15.7
0.9	10.7	13.0
0.9	11.7	15.1

Run 8

Vortex Finder 3.2 mm
Spigot Discharge 3.2 mm
Feed Density 10.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size μm
1.7	19.8	9.6
1.6	20.0	11.2
1.7	21.2	12.5

Table 1 (cont'd)

Run 9

Vortex Finder 3.2 mm
Spigot Discharge 4.8 mm
Feed Density 2.5%s

Feed Pressure p.s.i.	Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
30	0.2	3.1	17.6
40	0.3	3.1	17.0
50	0.2	3.1	13.5

Run 10

Vortex Finder 3.2 mm
Spigot Discharge 4.8 mm
Feed Density 5.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
0.7	7.1	17.0
0.8	6.9	14.6
0.7	6.8	12.5

Run 11

Vortex Finder 3.2 mm
Spigot Discharge 4.8 mm
Feed Density 7.5%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
1.1	9.0	14.6
1.3	8.9	11.2
1.2	8.9	14.0

Run 12

Vortex Finder 3.2 mm
Spigot Discharge 4.8 mm
Feed Density 10.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
1.8	12.4	13.5
1.9	12.4	16.3
1.9	12.2	14.6

Run 13

Vortex Finder 4.8 mm
Spigot Discharge 4.8 mm
Feed Density 2.5%s

Feed Pressure p.s.i.	Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
30	0.4	5.4	12.5
40	0.4	5.3	13.5
50	0.4	5.4	12.1

Run 14

Vortex Finder 4.8 mm
Spigot Discharge 4.8 mm
Feed Density 5.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
0.9	10.8	13.5
0.9	10.5	14.0
0.9	10.8	9.6

Run 15

Vortex Finder 4.8 mm
Spigot Discharge 4.8 mm
Feed Density 7.5%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
1.4	13.4	9.3
1.4	13.8	9.6
1.3	14.2	8.3

Run 16

Vortex Finder 4.8 mm
Spigot Discharge 4.8 mm
Feed Density 10.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
2.2	22.1	8.0
2.1	22.0	6.9
2.1	22.4	5.7

Table 1 (cont'd)

Run 17

Vortex Finder 4.8 mm
Spigot Discharge 3.2 mm
Feed Density 2.5%s

Feed Pressure p.s.i.	Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
30	0.4	11.3	9.3
40	0.4	10.7	9.6
50	0.4	10.9	7.1

Run 18

Vortex Finder 4.8 mm
Spigot Discharge 3.2 mm
Feed Density 5.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
1.0	21.1	10.4
0.9	21.1	9.6
0.9	21.8	8.0

Run 19

Vortex Finder 4.8 mm
Spigot Discharge 3.2 mm
Feed Density 7.5%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
1.5	28.3	8.3
1.5	30.6	9.3
1.6	29.6	7.6

Run 20

Vortex Finder 4.8 mm
Spigot Discharge 3.2 mm
Feed Density 10.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
2.3	39.5	8.0
2.2	39.2	7.4
2.3	41.1	6.1

Run 21

Vortex Finder 4.8 mm
Spigot Discharge 1.6 mm
Feed Density 2.5%s

Feed Pressure p.s.i.	Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
30	0.4	20.0	10.4
40	0.4	21.0	8.0
50	0.4	21.1	8.6

Run 22

Vortex Finder 4.8 mm
Spigot Discharge 1.6 mm
Feed Density 5.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
0.9	28.6	8.9
0.9	29.1	6.9
0.8	30.5	6.9

Run 23

Vortex Finder 4.8 mm
Spigot Discharge 1.6 mm
Feed Density 7.5%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
1.8	50.8	6.1
1.8	53.8	5.7
1.7	53.5	5.9

Run 24

Vortex Finder 4.8 mm
Spigot Discharge 1.6 mm
Feed Density 10.0%s

Cyclone Overflow %s	Cyclone Underflow %s	Cut point size µm
3.0	58.1	9.6
3.2	59.5	9.3
2.9	60.6	7.4

Table 2. Summary of conditions required for a range of cut point sizes for talc (94% -53µm), from 20µm to 5µm

Vortex Finder mm	Spigot Discharge mm	Feed Pressure p.s.i.	Feed Density %s	Cut point size µm
3.2	3.2	30	2.5	20.5
3.2	3.2	40	2.5	17.6
3.2	4.8	50	10.0	14.6
4.8	4.8	50	2.5	12.1
4.8	4.8	50	5.0	9.6
4.8	4.8	50	7.5	8.3
4.8	4.8	50	10.0	5.7

Table 3 Variation of the cut point size of -50µm barite, using 12.5%s feed density

Vortex Finder mm	Spigot Discharge mm	Feed Pressure p.s.i.	Cyclone Underflow %s	Cyclone Overflow %s	Cut point size µm
4.8	4.8	40	33.6	1.9	3 (7)
	3.2	40	57.8	2.2	3 (7)
	1.6	40	81.4*	3.2	4 (9)
4.8	4.8	50	35.1	1.8	2 (6)
	3.2	50	58.6	2.0	3 (6)
	1.6	50	79.1*	3.5	5 (7)

* Cyclone underflow was roping

APPENDIX 1

APPENDIX I

14/1986

OPERATOR: L.MORIN

SAMPLE: KAOLIN CYCLONE OVERFLOW
SAMPLE DENSITY: 2.6 G/CC

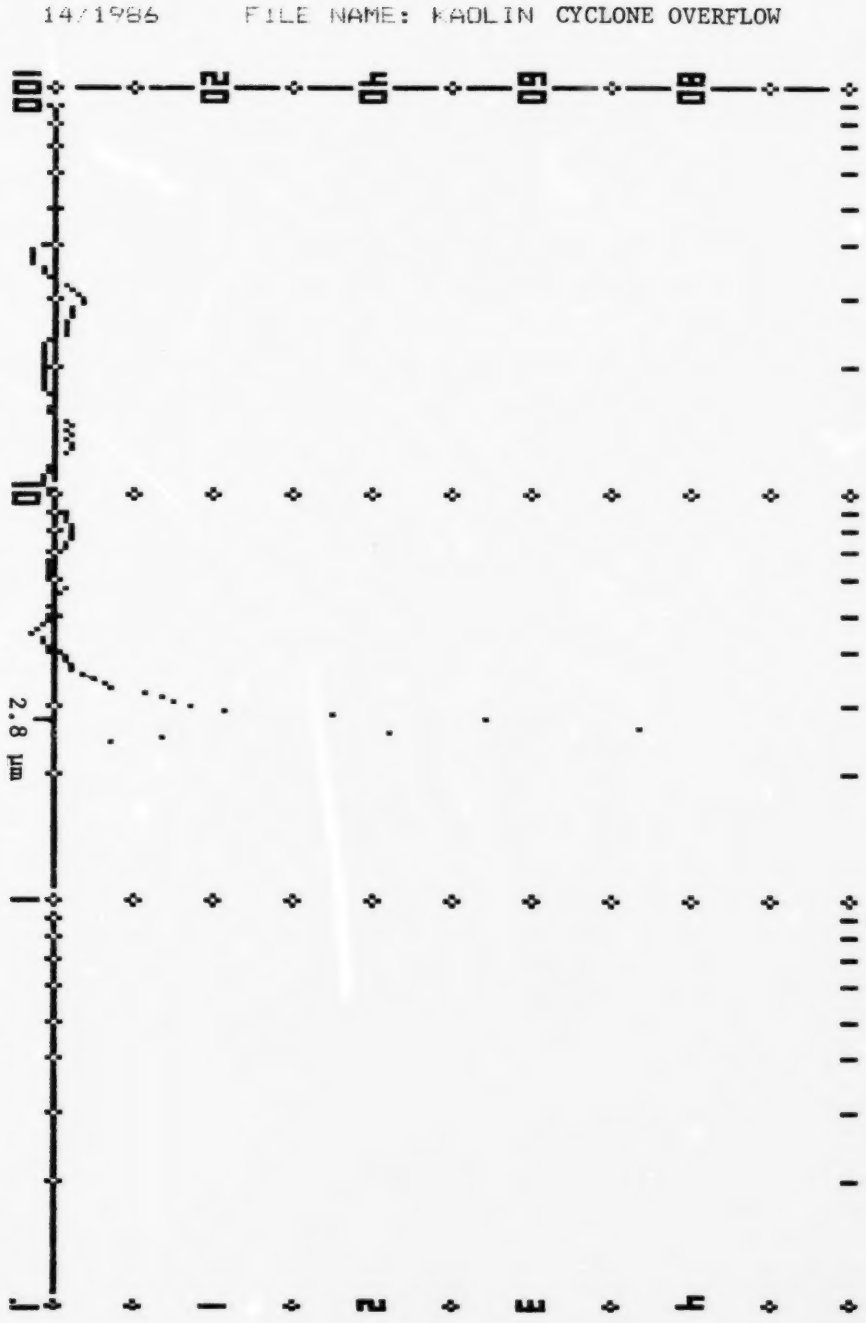
LIQUID: WATER
TEMPERATURE: 32 DEGREES CELSIUS
LIQUID DENSITY: .9951 G/CC
VISCOSITY: .7679 CENTIPOISE

PRINCIPAL PARTICLE DIAMETERS (MICRONS)
STARTING: 50 ENDING: 1.11 MAXIMUM: 41

RUNNING TIME: 1 HR 33 MIN RATE: 443

PARTICLE SIZE (MICRONS)	PERCENT FINER (%)	CHANGE (%)	RATE OF CHANGE (% / INCR)
50	99	1	0
40	99	0	-.1
30	99	0	.15
20	100	-1	-.1
10	100	0	-.05
9	100	0	0
8	99	1	.1
7	99	0	0
6	99	0	-.05
5	99	0	0
4	100	-1	0
3	98	2	.85
2	105	-7	-.5

END OF DATA


14/1986 FILE NAME: KAOLIN CYCLONE OVERFLOW
100
90
80
50
20
10
2.8 µm
1
1
2
3
4

OCTOBER 10/1986

OPERATOR: L.MORIN

SAMPLE: KAOLIN **CYCLONE UNDERFLOW**
SAMPLE DENSITY: 2.6 G/CC

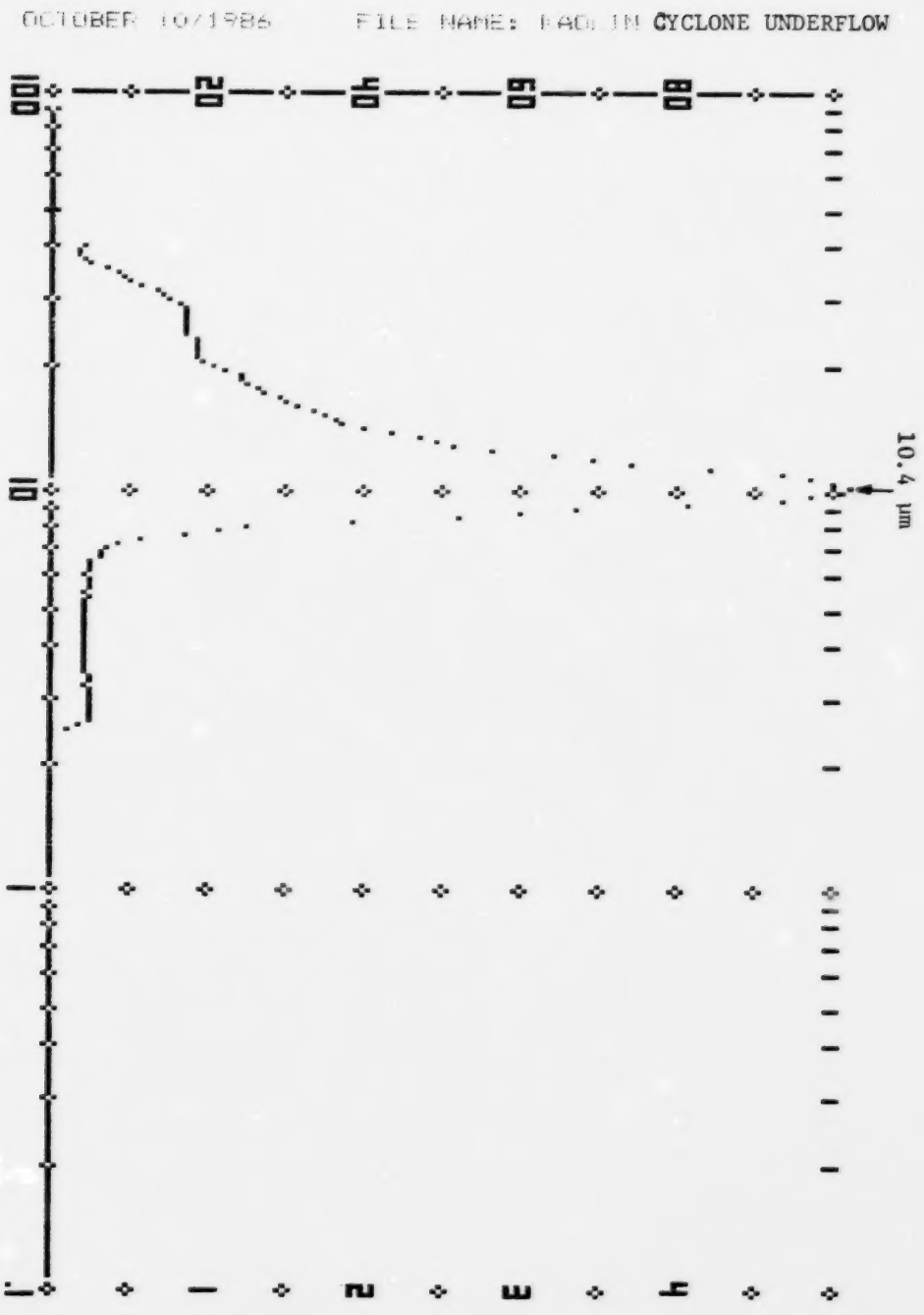
LIQUID: WATER
TEMPERATURE: 31 DEGREES CELSIUS
LIQUID DENSITY: .9954 G/CC
VISCOSITY: .784 CENTIPOISE

PRINCIPAL PARTICLE DIAMETERS (MICRONS)
STARTING: 50 ENDING: 1.14 MAXIMUM: 41

RUNNING TIME: 1 HR 35 MIN RATE: 433

PARTICLE SIZE (MICRONS)	PERCENT FINER (%)	CHANGE (%)	RATE OF CHANGE (% / INCR)
50	99	1	0
40	98	1	.2
30	94	4	.75
20	83	11	1.1
10	36	47	5.1
9	17	19	4.05
8	9	8	1.25
7	7	2	.3
6	6	1	.2
5	5	1	.2
4	4	1	.2
3	2	2	.25
2	0	2	-.5

END OF DATA


OCTOBER 10/1986
FILE NAME: FAC IN CYCLONE UNDERFLOW
100
90
80
50
10
1
1
2
3
4
10.4 µm